Multi-vendor bay solutions & their interoperability performances in a fully digital substation

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Motivations

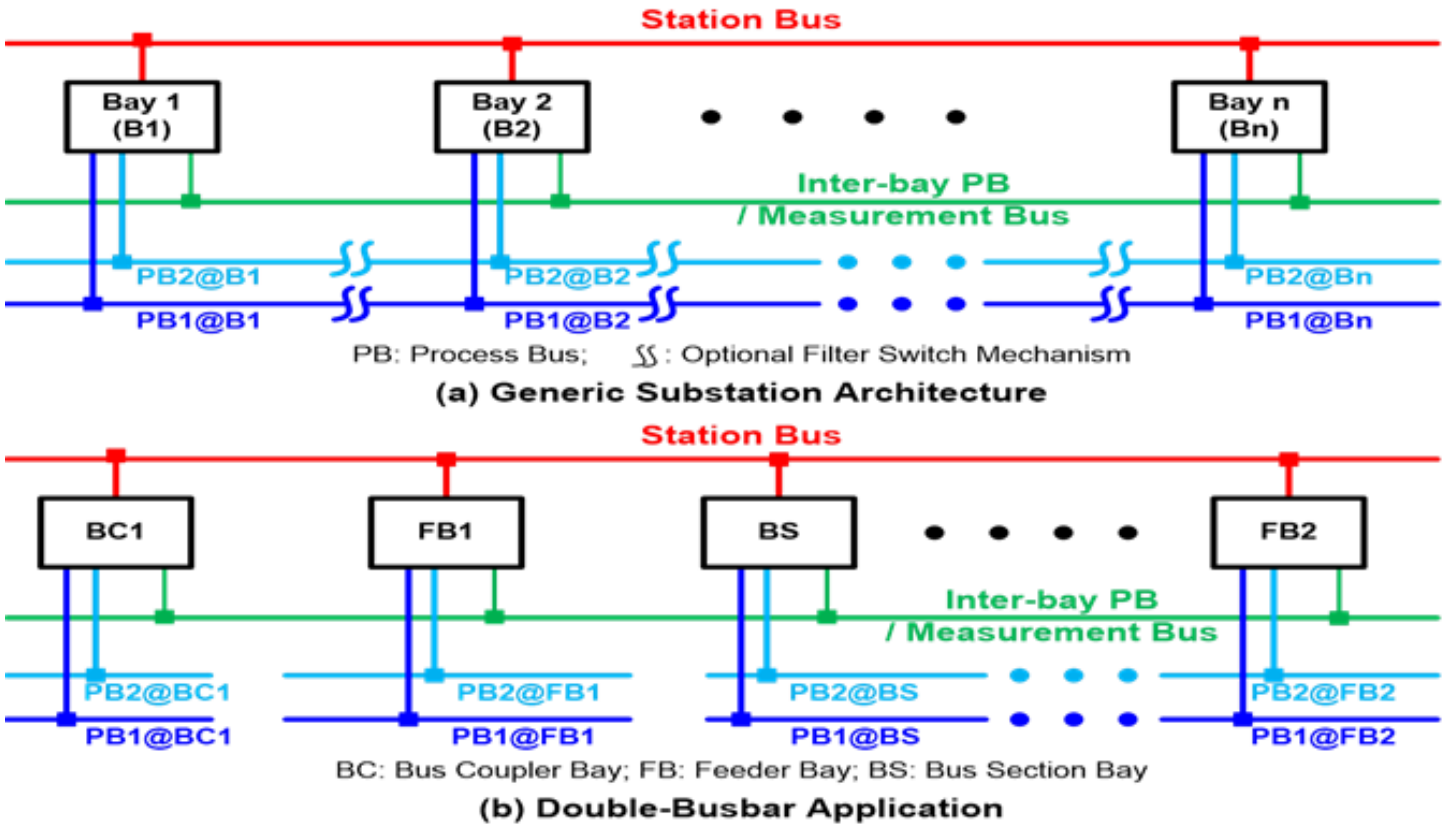
- IEC 61850 interoperability between various vendor products has been researched by many studies. However, the testing is usually based on a dedicated device-to-device method, and hence the system integration is relatively simple compared to the integration of a real substation with multiple bay suppliers. Also, the interoperability issues concerned with inter-bay or station-wide applications have not been thoroughly investigated.

- This paper presents the design methodology for a digital substation PAC system integrating multi-vendor bay solutions

Objectives

- To carry out modelling and simulations for any design of NG substations to create a virtual site substation simulation testing environment,
- To implement a configurable and extensible Architecture of Substation Secondary System (AS3) test platform using real amplifiers for secondary signal injections, real analogue to digital merging units, real circuit breaker control I/O units, to provide the standardised secondary system interfaces to the primary plant.
- To support and facilitate multi vendors IED interoperability and performance testing. This study will ensure solutions from different suppliers will work correctly, safely and reliably,
- To provide testing and training facility.

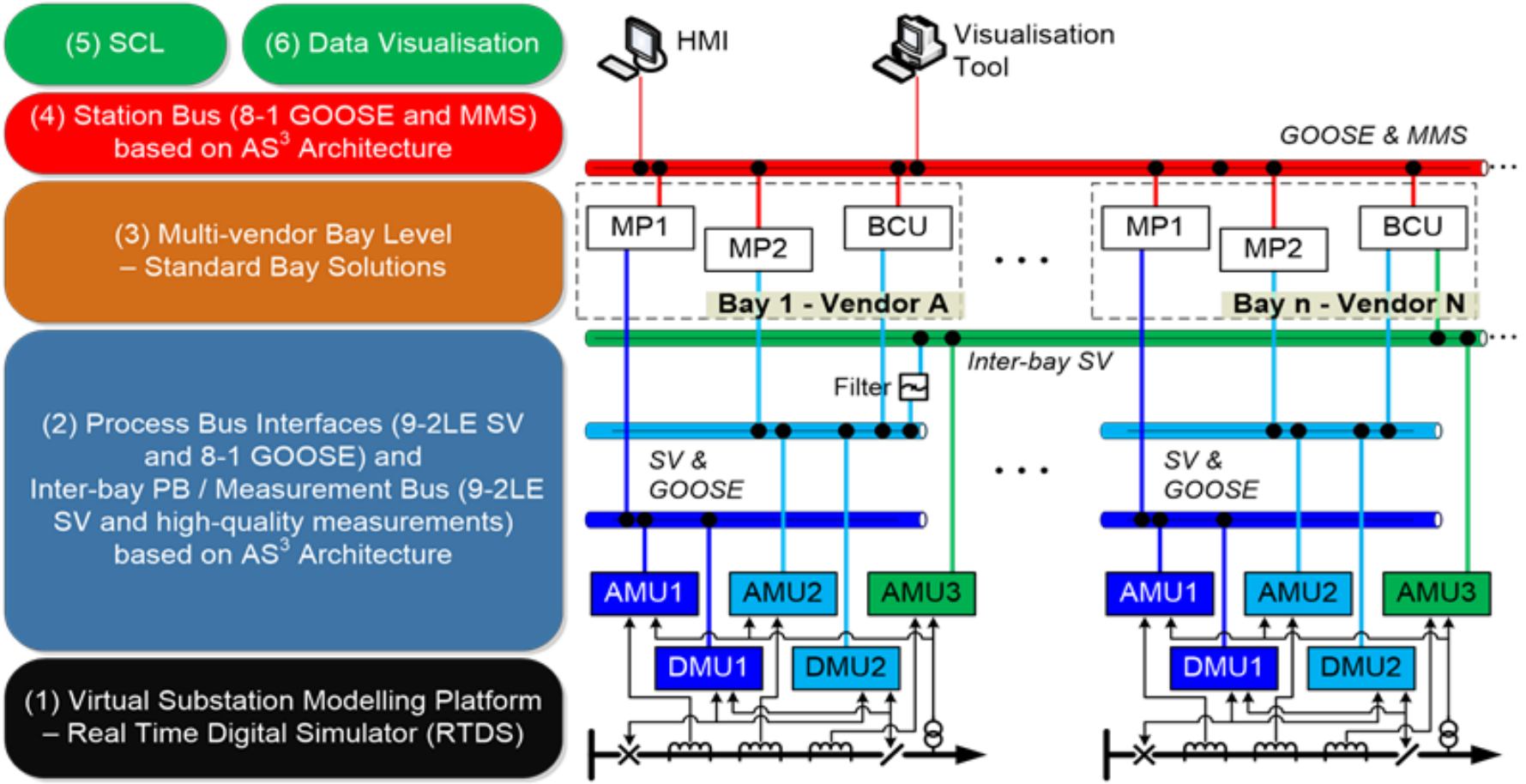
Design of AS3 Architecure



- Independent process buses PB1 and PB2
- Measurement bus for high accuracy metering and synchronising
- Standard bay solutions
- Station bus network for substation automation and control.

- A standardised, reliable and flexible IEC 61850 based communication architecture (AS3) can reduce outage time and cost associated with commissioning, maintenance and replacement of Protection Automation and Control (PAC) solutions

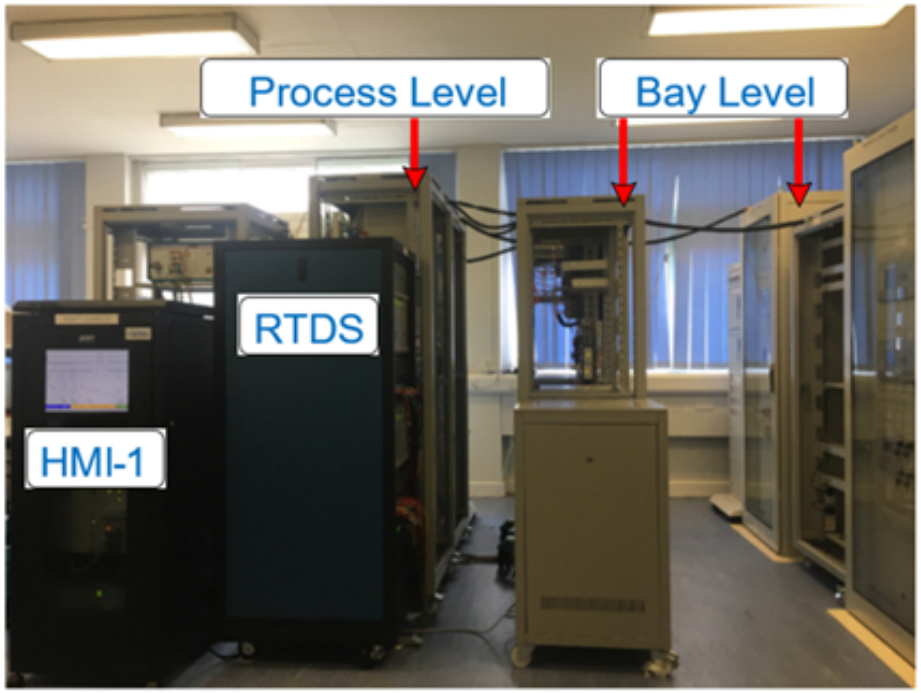
Virtual Site Tests using a VSATT Platform



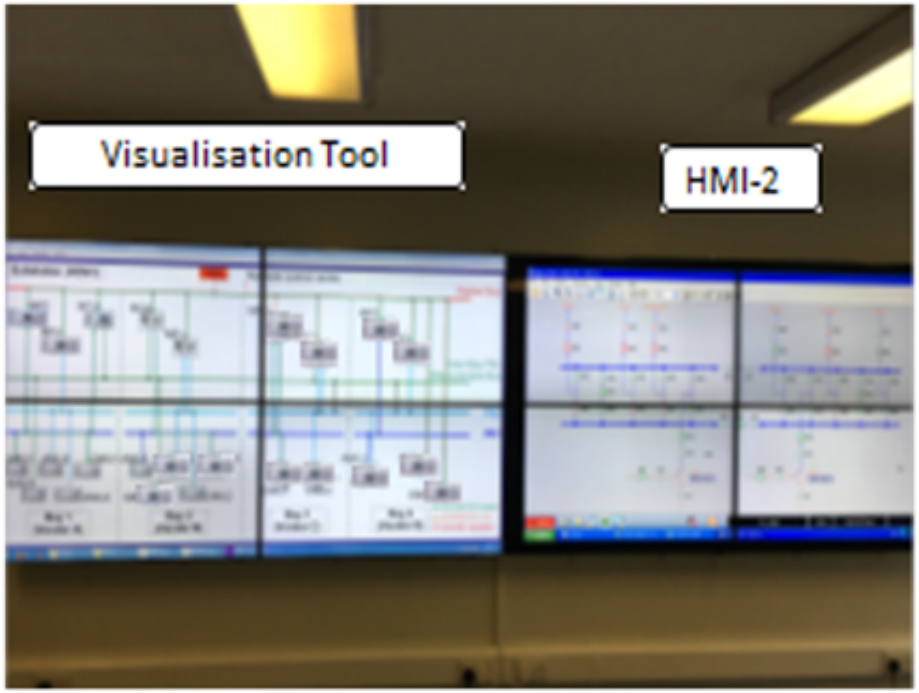
- Filter: Data filtering function based on MAC Destination Address or VLAN

- To assess and test the viability of AS3 architecture design, National Gird and the University of Manchester have established a lab-based Virtual Site Acceptance Testing and Training (VSATT) facility in collaboration with several key supplies of PAC solutions.

Lab layout of the VSATT platform



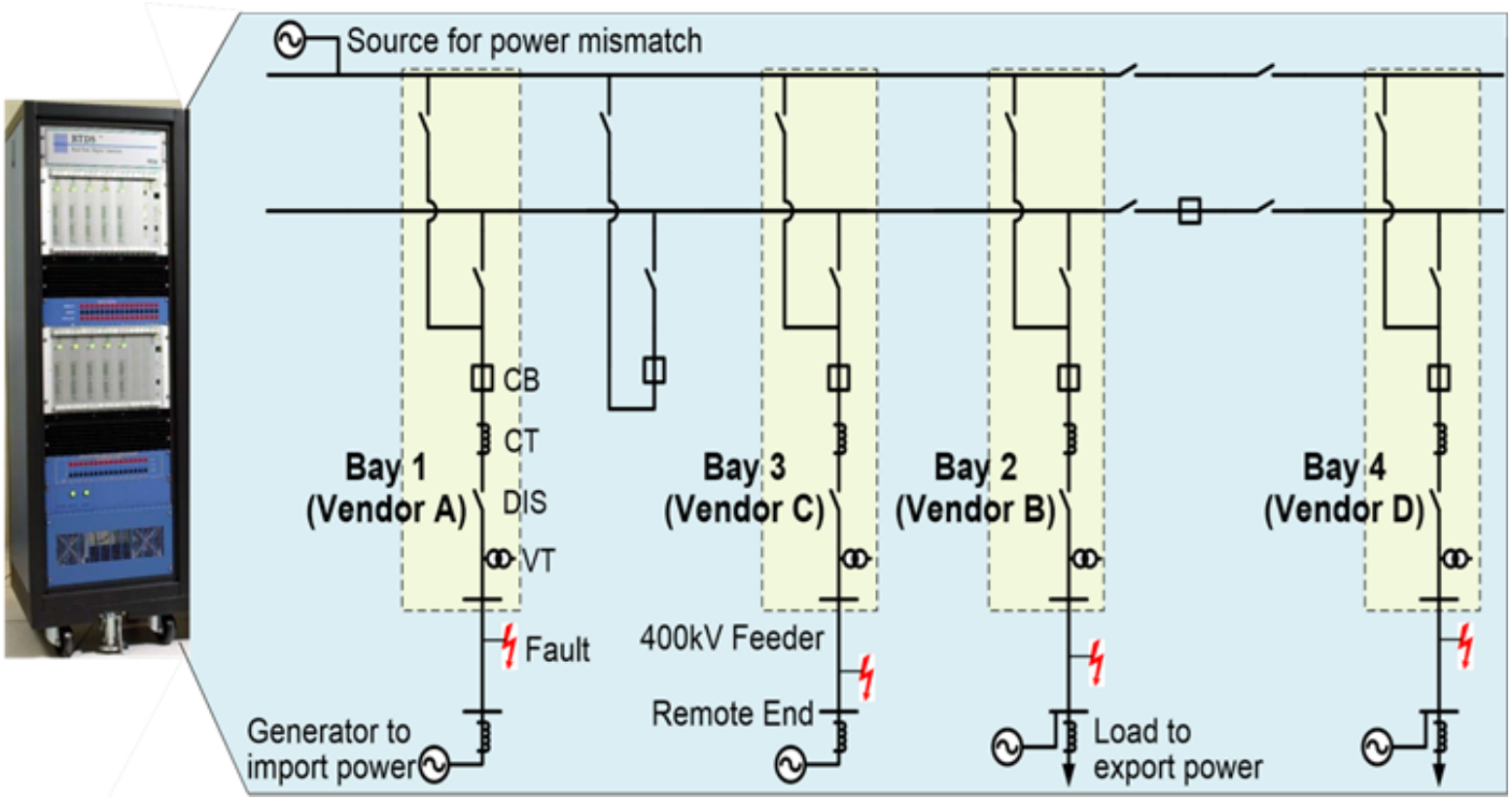
(a) Hardware Platform



(b) Monitoring Tools

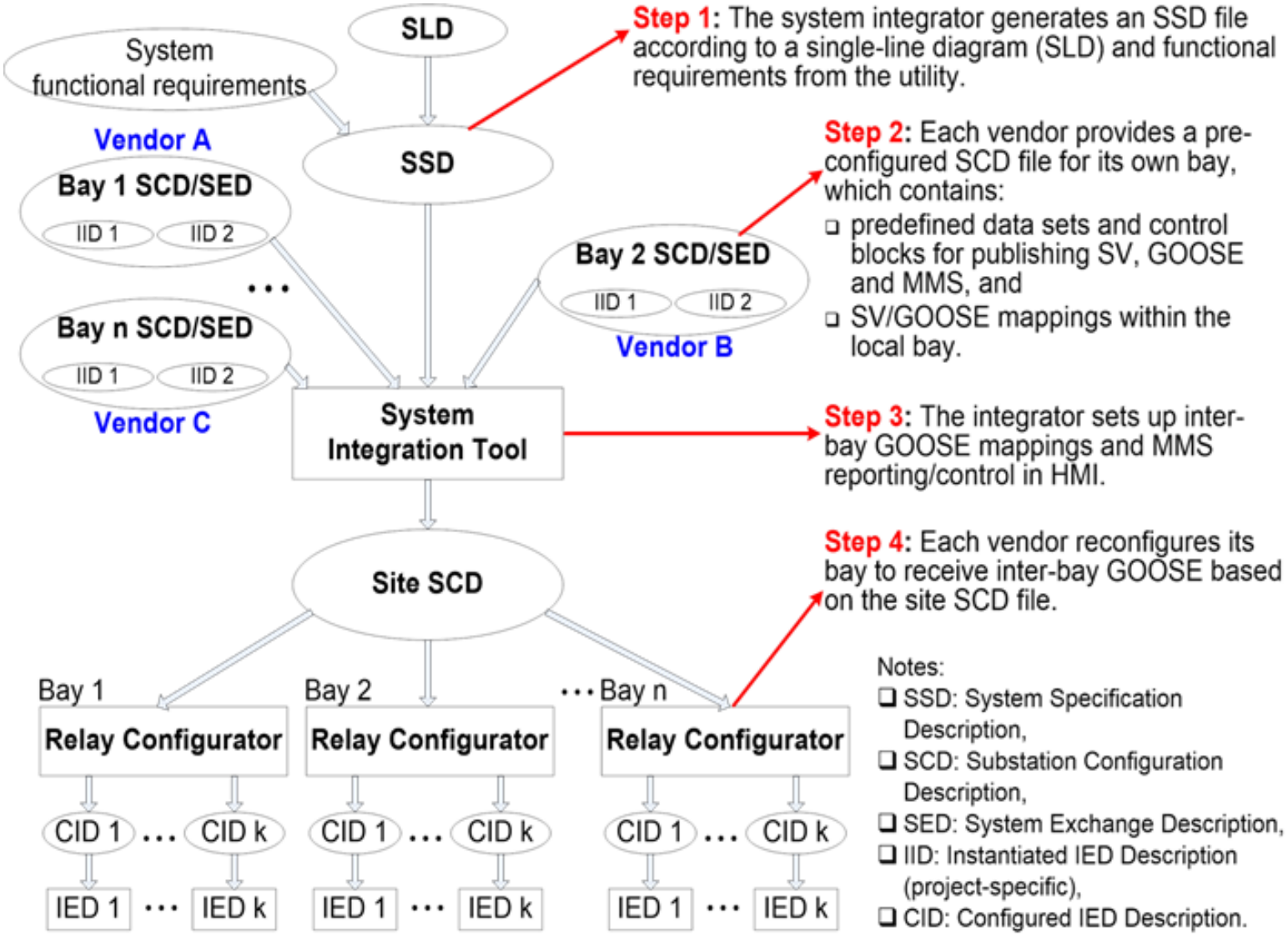
- The figure shows the hardware layout of the VSATT platform and monitoring tools, including data flow visualization tool

Substaiton Modelling using RTDS



- The figure above illustrates the simulated VSATT substation model based on a National Grid 400kV double-busbar substation, which has been implemented using a RTDS.

Integration with a SCL Tool



Step 1: The system integrator generates an SSD file according to a single-line diagram (SLD) and functional requirements from the utility.

Step 2: Each vendor provides a pre-configured SCD file for its own bay, which contains:

- predefined data sets and control blocks for publishing SV, GOOSE and MMS, and
- SV/GOOSE mappings within the local bay.

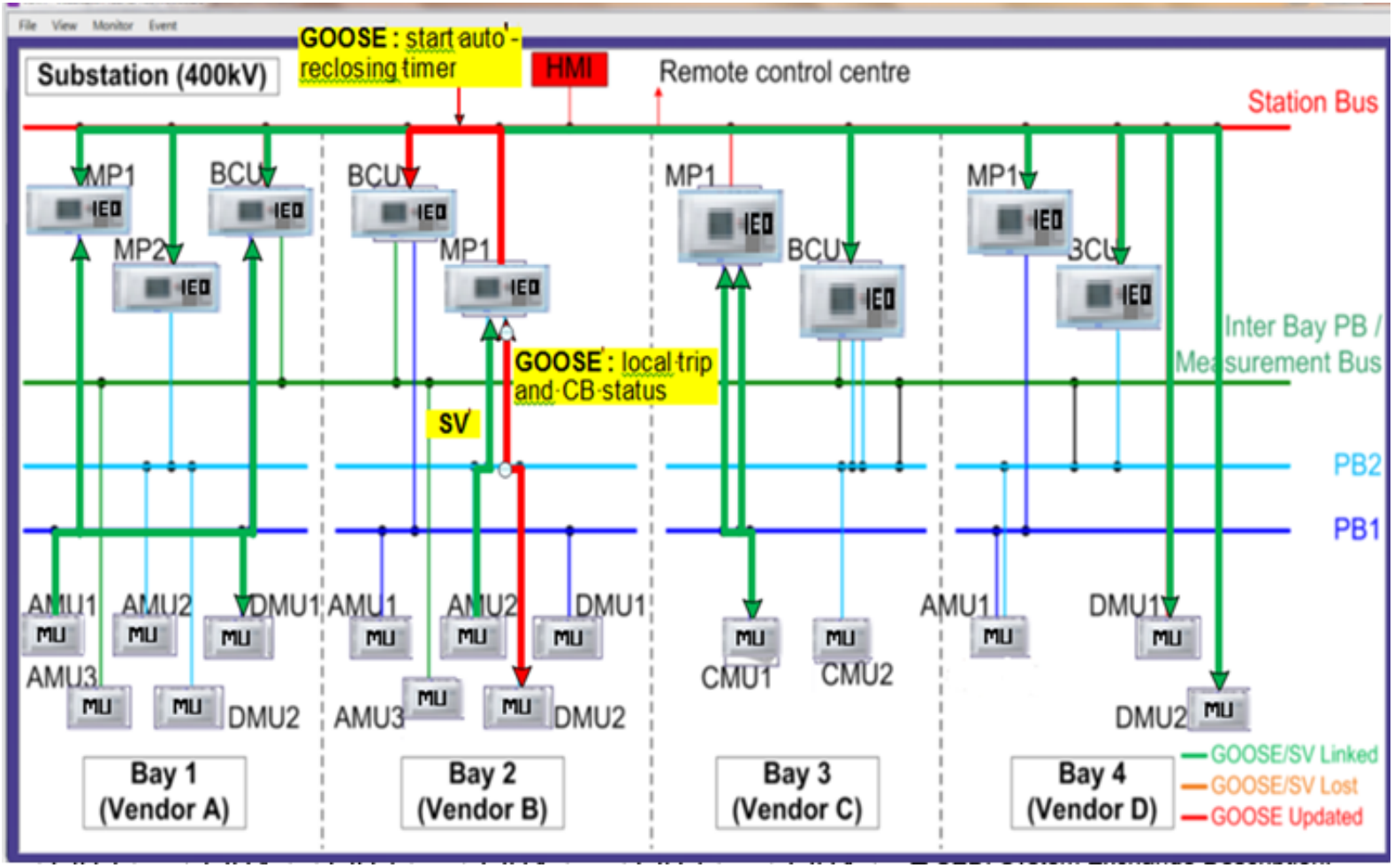
Step 3: The integrator sets up inter-bay GOOSE mappings and MMS reporting/control in HMI.

Step 4: Each vendor reconfigures its bay to receive inter-bay GOOSE based on the site SCD file.

Notes:

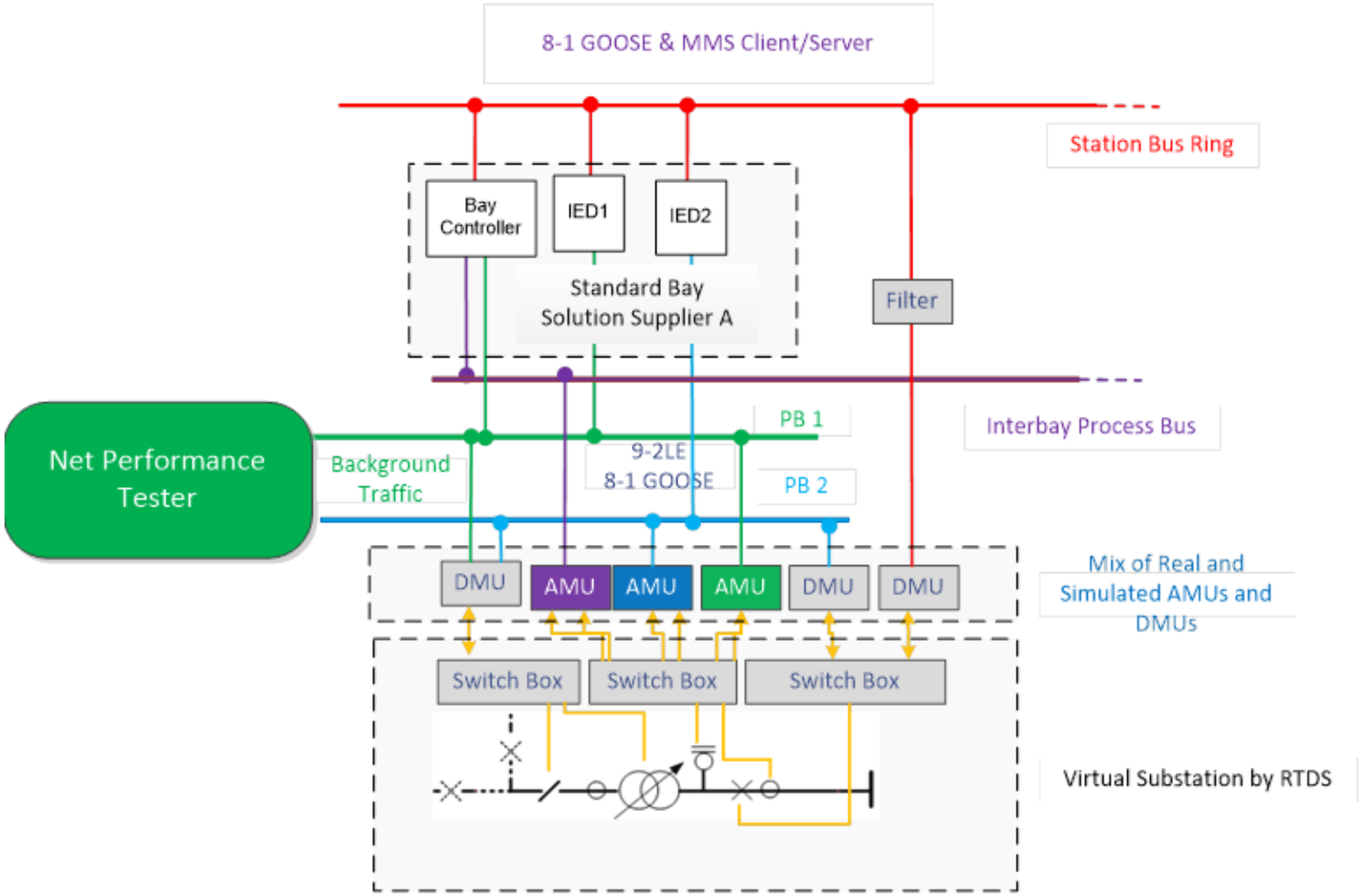
- SSD: System Specification Description,
- SCD: Substation Configuration Description,
- SED: System Exchange Description,
- IID: Instantiated IED Description (project-specific),
- CID: Configured IED Description.

In house Visulisation Tool



- To validate the relevant message, the developed visualisation tool was connected to PBS during the tests.
- The tool can indicate data changes with the source IRDs, Logical Devices (LDs), LNs, Dos and time samples.

Interoperability Tests at PBs

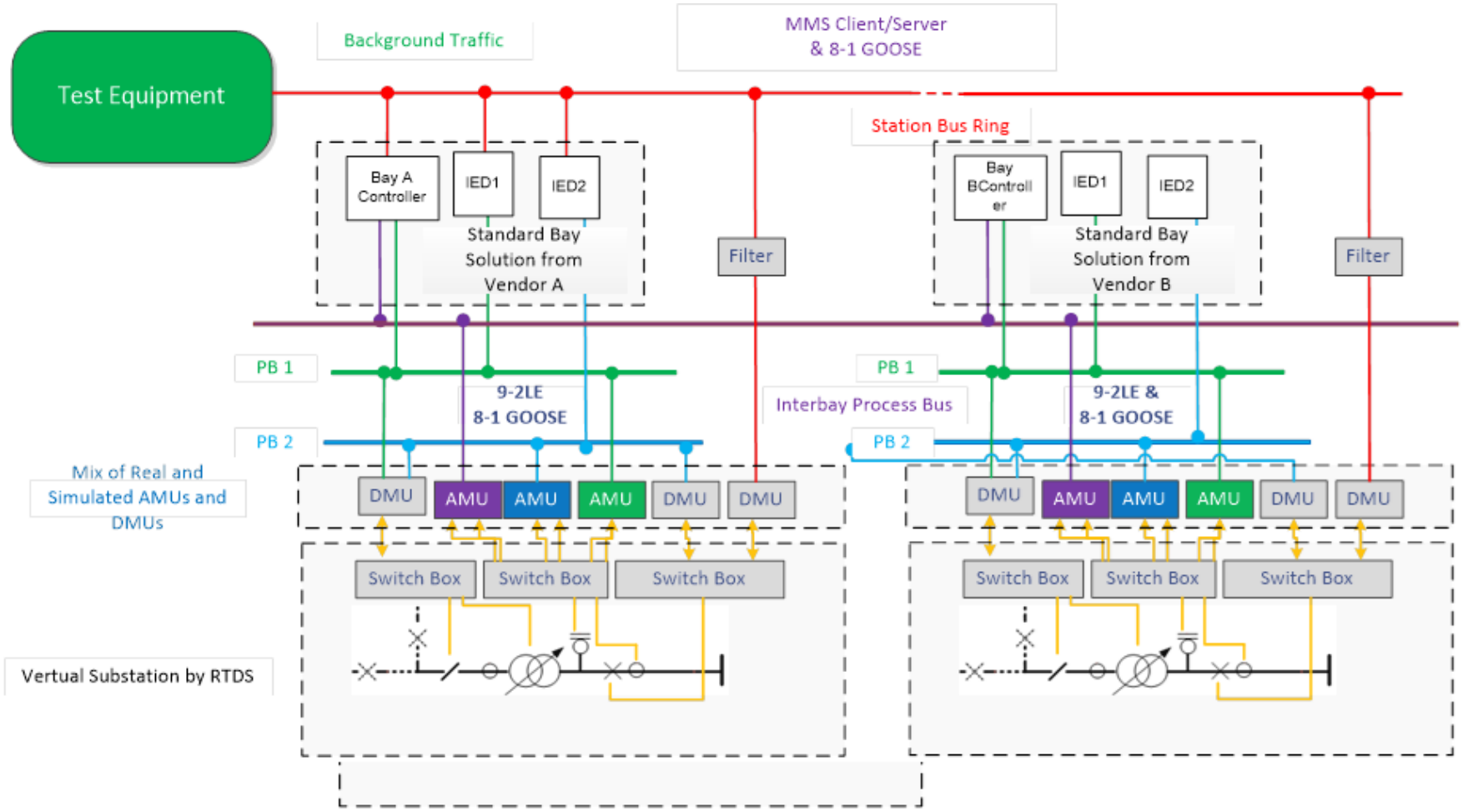


Interoperability test scenarios

- With different combinations of equipment

Test Scenario NO.	Bay Equipment	Test Type
1	AMU1 and MP1	Test Case 1
2	AMU1 and BCU	Test Case 1
3	AMU2 and MP2	Test Case 1
4	DMU1 and MP1	Test Case 2
5	DMU1 and BCU	Test Case 2
6	DMU2 and MP2	Test Case 2

Interoperability tests between bays



Interoperability test scenarios

- **List of test scenarios for Station Bus**

Test Scenario NO.	Equipment	Test Type
1	HMI and BCU	Test Case 3
2	HMI and BCU	Test Case 4
3	BCUs from two different vendor bays	Test Case 5
4	BCUs from two different vendor bays	Test Case 6

Conclusions

- This paper presents the development of a multi-vendor test platform to investigate the key aspects of IEC 61850, including architecture, system integration, SCL tool, data monitoring tool and interoperability tests.
- The studies have shown that the interoperability between IEDs from different vendors is still not yet seamless. The interoperability issues regarding SCL tools and protocols are discussed in details.